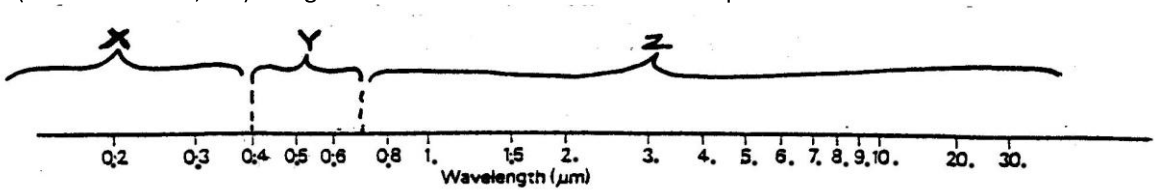
GC 170A! FALL 2012 INTRODUCTION TO GLOBAL CHANGE
PRACTICE FINAL EXAM QUESTIONS, ORGANIZED BY TOPIC

Here are practice questions that are good examples of the types of questions that will be on the final exam. I can't give you practice on *every* kind of question I will ask, and on *every* topic I will ask about, but the practice questions should help you get a good idea of what the exam will be like and will help you review some key concepts. (One or two questions are from previous semesters when more time may have been spent on a particular topic, but you should be able to handle these as well. See the Answer Key if you can't.)

NOTE: For additional practice, BE SURE your review the questions in Self Checks / Readiness Quizzes and In-Class Tests, especially Test #3 & Test #4 (and their corresponding "Top 10 guides").
One or more questions from ANY of these could reappear on the Final Exam!!

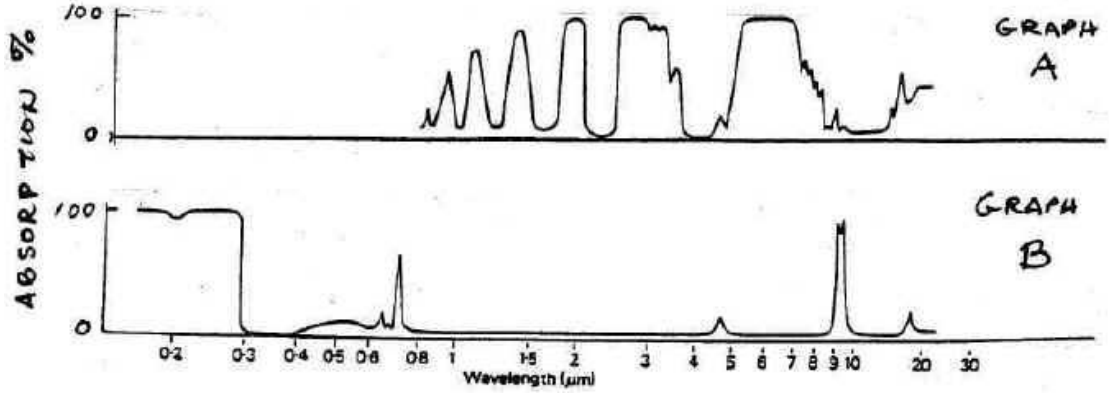
POSSIBLE QUESTIONS WHICH REVIEW IMPORTANT CONCEPTS FROM FIRST HALF OF COURSE:

Questions # 1 - 3 refer to the figure below which represents a portion of the **Electromagnetic Spectrum** with wavelengths shown (in micrometers, μm) along a horizontal line and sections of the spectrum bracketed and labeled.



1. Which bracketed section of the spectrum represents visible light? *(Circle one)* X Y Z
2. Which bracketed section of the spectrum represents infrared wavelengths? *(Circle one)* X Y Z
3. Which bracketed section of the spectrum represents ultraviolet wavelengths? *(Circle one)* X Y Z

Questions #4 & # 5 refer to the graphs below which depict the *absorption* of different wavelengths of electromagnetic energy by different gases in the atmosphere. (NOTE: These graphs are sometimes referred to as "atmospheric absorption bands." Note also that the wavelength scale is a log scale.)



:

4. **GRAPH A** depicts absorption:

a) of the visible light part of the spectrum
b) of mostly ultraviolet radiation
c) of mostly incoming shortwave radiation
d) by one of the Greenhouse gases

5. **GRAPH B** depicts absorption

a) over ALL wavelengths
b) of all wavelengths except the visible part of the spectrum
c) of only infrared radiation, making this a Greenhouse gas
d) of a greenhouse gas that also absorbs ultraviolet radiation

POSSIBLE QUESTIONS ON THE ENERGY BALANCE

6. Complete the ENERGY BALANCE EQUATION by filling in the proper cartoon symbols in the blanks:
[Hint: most of the symbols you need will appear in the practice questions below]

R_{net} = _____ + _____ - _____ - _____ + _____ = _____ + _____ + **G**

7. Energy transfer by means of **large-scale movements of material** within a fluid (liquid or air) occurs in **which one** of the following processes:

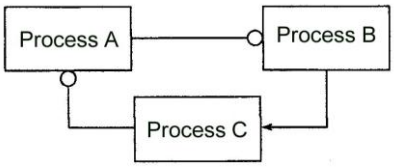
a) convection b) conduction c) LE d) 

e) 

8. Energy transfer by **waves or pulses of energy** that involve **photons** occurs in **which one** of the following processes:

a) **H** b) convection c) **G** d) 

POSSIBLE QUESTIONS ON FEEDBACKS



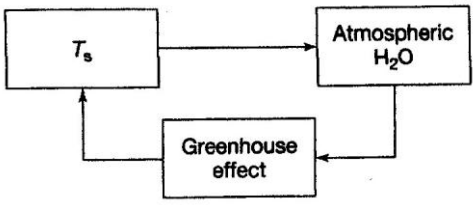
9. The figure at right is a feedback loop. Which of the following choices properly describes the nature of the feedback depicted in the diagram:

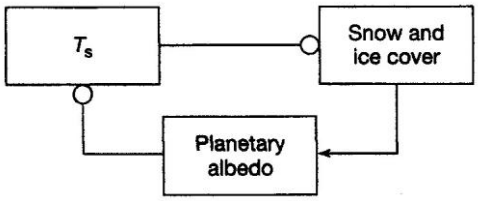
a) If A *increases*, B will *also increase*; when B *increases*, C will *also increase*; when C *increases*; A will *also increase*. Hence the loop is a **POSITIVE** feedback loop.

b) If A *increases*, B will *decrease*; when B *decreases*, C will *increase*; when C *increases*, A will *decrease*. Hence the loop is a **NEGATIVE** feedback loop.

c) A & B are *positively* coupled, B & C are *negatively* coupled, and C & A are *positively* coupled. Hence the whole loop is a **NEGATIVE** feedback loop.

d) If A *increases*, B will *decrease*; when B *decreases*, C will *also decrease*; when C *decreases*, A will *increase*. Hence the loop is a **POSITIVE** feedback loop.





10. Which statement about the feedback loops depicted in the diagrams above is correct?
(NOTE: Ts = Temperature of the Earth's surface)

a) They are both positive feedback loops because if Ts increases, the eventual result will be an amplification of global warming
b) They are both negative feedback loops because if Ts increases, the eventual result will be an adjustment to the to the initial increase of Ts so that no further global warming occurs
c) The left diagram represents a negative feedback loop because water vapor in the atmosphere will cool things down after the initial increase in Ts
d) The right diagram represents a negative feedback loop because an increase in Ts will cause the snow and ice to melt, lower the albedo and eventually result in an amplification of the libido effect.
e) None of the above

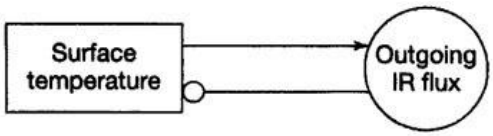
POSSIBLE SHORT ANSWER / ESSAY QUESTION ON FEEDBACKS:

11. Both of the feedback loops below involve the Earth's **surface temperature** (abbreviated as "**Ts**" in Loop Y). Feedback Loop X "self-regulates" the Earth's surface temperature and keeps it livable (i.e., not too cold, not too hot), but Feedback Loop Y depicts a different process involving temperature. **Describe the difference between Feedback Loop X and Feedback Loop Y by :**

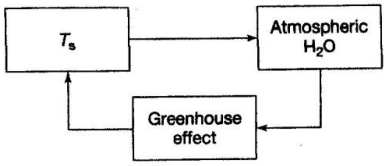
(a) stating whether each feedback loop is **positive or negative**, and

(b) explaining how the **components and couplings in each feedback loop work together** to influence the Earth's surface temperature.

FEEDBACK LOOP X



FEEDBACK LOOP Y



12. Can you reason your way through the **unlinked couplings on p 61 in CLASS NOTES** and add the proper box-and-arrow symbols that the SGC text uses? (HINT #1: The right-hand figure in #10 above may help you with your reasoning. HINT #2: Start with the component box labeled "ocean temperature" and proceed clockwise around the loop.)

POSSIBLE QUESTIONS WHICH TIE THE ENERGY BALANCE TO SEVERAL DIFFERENT KEY COURSE CONCEPTS

FOR QUESTIONS 13-16: You are designing a computer model to simulate the energy balance of the Earth & atmosphere under global change conditions. You know that different kinds of global changes will affect different parts of the energy balance. For each of the following global change scenarios, **CIRCLE THE LETTER of the symbol representing the <u>correct model adjustment</u> you will have to make** in your model of the energy balance to properly simulate how the earth/atmosphere system will respond to the change.

NOTE: "MORE" means that the proportion of energy in this part (symbol) of the balance will INCREASE after the global change scenario takes place, and "LESS" means that the proportion of energy in this part of the balance will DECREASE after the global change scenario takes place.

13. SCENARIO: **CFC's destroy** large amounts of **ozone** in the **stratosphere** depleting the ozone layer and producing an "Ozone Hole." MODEL ADJUSTMENT:

(a) **MORE UV** SW ↓ (b) **LESS UV** SW ↓ (c) **LESS** LW ↓ (d) **LESS LE**

14. SCENARIO: The **increased burning of fossil fuels** produces more and **more CO_2** in the atmosphere.
MODEL ADJUSTMENT:

(a) **MORE** SW ↘ (b) **MORE** LW ↓ (c) **MORE** SW ↓ (d) **MORE LW (to space)** LW ↑

15. SCENARIO: A new International Climate Treaty signed in Cancún in December 2010 is able to produce a significant **reduction** in global greenhouse gas emissions by the year 2050. MODEL ADJUSTMENT:

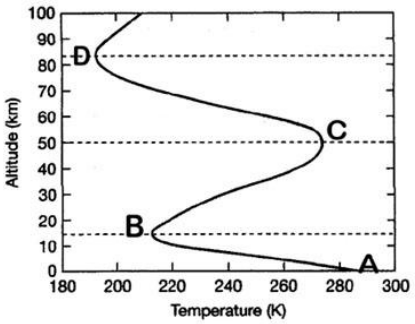
(a) **MORE** SW ↓ (b) **MORE** SW ↘ (c) **MORE** LW ↓ (d) **LESS** LW ↓

16. SCENARIO: Deforestation occurs in the Amazon rain forest occurs, changing the land from lush forest to bare grazing and crop land. MODEL ADJUSTMENT:

(a) more **LE** (b) less **H** (c) more SW ↗

POSSIBLE QUESTIONS ABOUT ATMOSPHERIC STRUCTURE & COMPOSITION

(review from first half of semester – this is another example of key concepts that carry over to the second half of the semester.)



Questions 17 –19 Referring to the diagram at left, give the names of the following layers of the atmosphere:

17. The layer from A to B is named: _____

18. The layer from B to C is named: _____

19. The layer from C to D is named: _____

20. The layer above D is named: _____

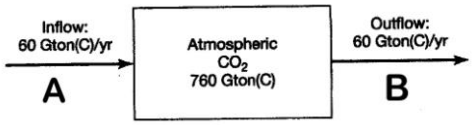
21. The layer where the **Greenhouse Effect** has its greatest influence: is: (a) A to B (b) B to C (c) C to D (d) Above D

22. What the temperature response will be after a major climatic effective explosive volcanic eruption:

(a) warming in Layer A to B and cooling in Layer B to C
(b) cooling in Layer A to B and warming in Layer B to C
(c) cooling in Layer A to B & in Layer B to C
(d) warming in Layer A to B & in Layer B to C

POSSIBLE QUESTIONS ON CARBON RESERVOIRS & FLUXES:

23. The figure below depicts the **atmospheric carbon reservoir**, which receives an influx of 60 Gtons of carbon per year due to **Inflow A**, and from which a flux of 60 Gtons of carbon per year due is removed due to **Outflow B**. Which choice below correctly **identifies the processes involved in Inflow A and Outflow B:**



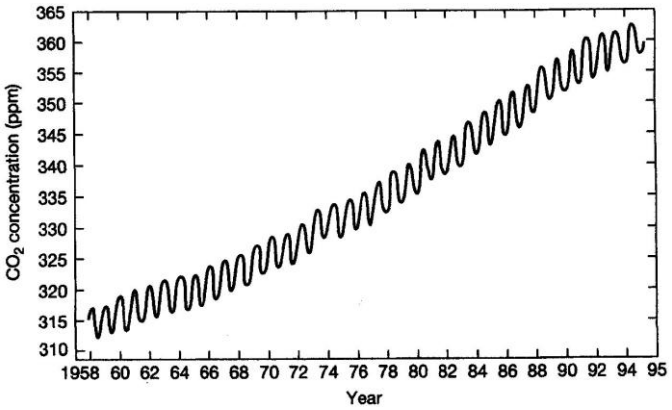
a) Inflow A is photosynthesis and Outflow B is respiration

b) Inflow A is respiration and Outflow B is photosynthesis

c) Inflow A is photosynthesis and Outflow B is atmospheric residence time

d) Inflow A is volcanic CO_2 and Outflow B is combustion and decomposition

24. The figure at right is the **Keeling curve** which shows an increasing trend of atmospheric CO_2 concentration in the atmosphere from 1958 to1995. (The measurements were taken on top of Mauna Loa in Hawaii.) The reason for the short term quasi-periodic fluctuations (i.e., the **annual zig-zags**) in the overall trend line is:



a) seasonal "breathing" by the ocean as it dissolves sea-floor carbonates

b) seasonal periods when photosynthesis > respiration followed by periods when respiration > photosynthesis

c) seasonal outgassing from Hawaiian volcanoes

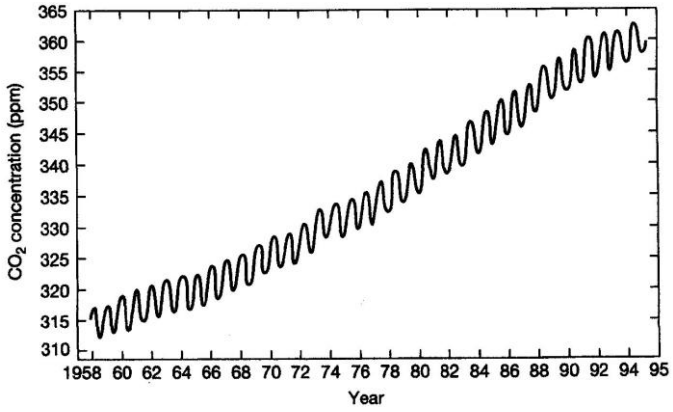
d) seasonal releases of methane from landfills

e) seasonal increases in tourism in the Hawaiian Islands

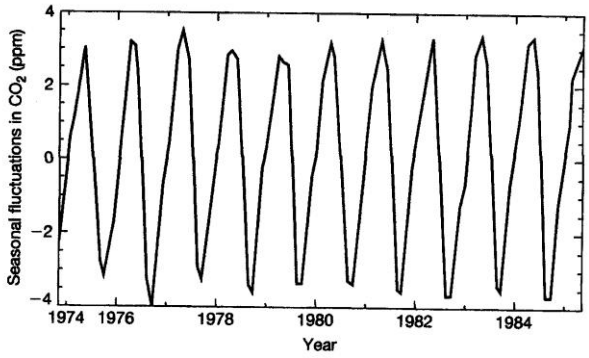
25. SHORT ANSWER QUESTION: The figures below represent two views of the KEELING Curve of changing concentration of atmospheric CO_2. Briefly explain the reasons for:

(a) Graph A's overall increasing trend & (b) Graph B's seasonal fluctuations.

GRAPH A



GRAPH B



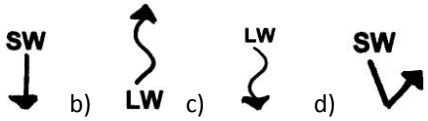
POSSIBLE QUESTION ON THE DIRE PREDICTIONS TEXT:

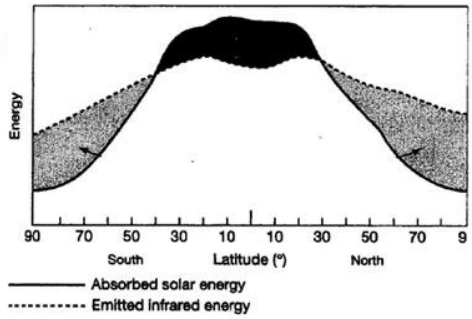
26. Name at least three "dire predictions" of IMPACTS that are likely to result from increased global warming:

• _____ • _____ • _____

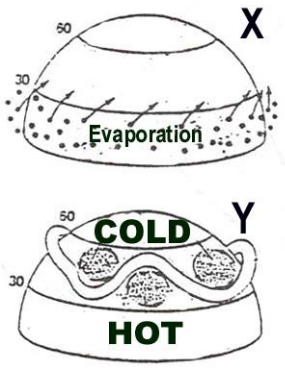
POSSIBLE QUESTIONS TYING THE ENERGY BALANCE TO ATMOSPHERIC & OCEANIC CIRCULATION :

27. Which of the following cartoon symbols (a,b,c, or d) from the energy balance equation is represented by the DASHED line in the figure to the right? ==>:





28. The figure at right is illustrating two ways we discussed in class by which the **low latitude surplus of energy** (shown in solid black in the figure for #27) **is redistributed to higher latitudes where there is an energy deficit** (shown in gray in the figure for #27). Which statement below *CORRECTLY* describes **one** of the mechanisms of energy transport being illustrated:



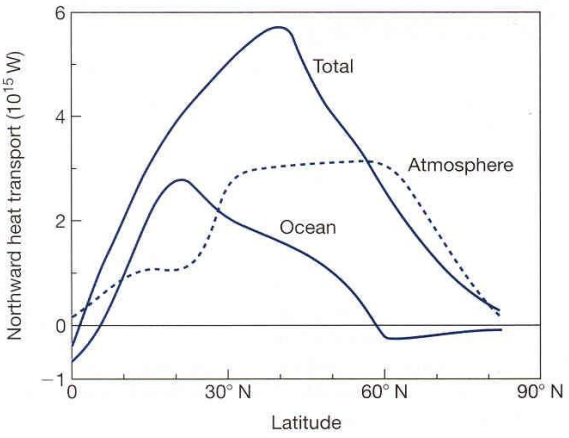
a) X shows how energy is stored in the tropics in the form of **H (sensible heat)** so that it can later be released as **LE (latent energy)** at higher latitudes when it condenses.

b) X shows how energy is stored in the tropics in the form of **LE (latent energy)** so that it can later be released as **H (sensible heat)** at higher latitudes when it condenses.

c) Y shows how energy is stored in the tropics in the form of **LE (latent energy)** so that it can be evaporated at higher latitudes where it is released as **H (sensible heat)**

d) Y shows how surplus **infrared energy** in the tropics is redistributed to higher latitudes by Rossby wave circulation

29. The figure at right shows the poleward heat (energy) transport in the Northern Hemisphere by the atmosphere separately (dashed line), the ocean separately (lower solid line) and both the atmosphere and ocean together (upper solid line).



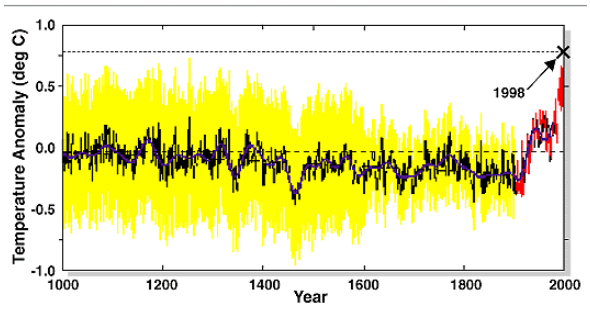
Which of the following statements about the OCEAN'S role in energy transport are true, based on the figure (check all that apply):

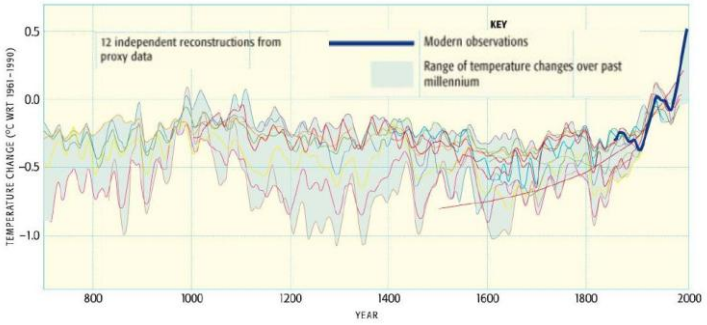
a) the ocean represents only a **small reservoir** of heat energy
b) the ocean transports **more** heat energy **to the poles** than the atmosphere transports
c) the ocean transports **more** heat energy poleward **at low latitudes** than the atmosphere transports
d) the ocean transports **less** heat energy poleward **at low latitudes** than the atmosphere transports

30. Follow up "connection" question:
The latitude belt where the greatest total poleward energy transport is taking place is ~ **35- 40° N latitude** in the figure above. What's happening **at this same latitude band** on the Energy Balance (Surplus/Deficit) figure in # 27 above? **Briefly explain the connection between the two figures.**

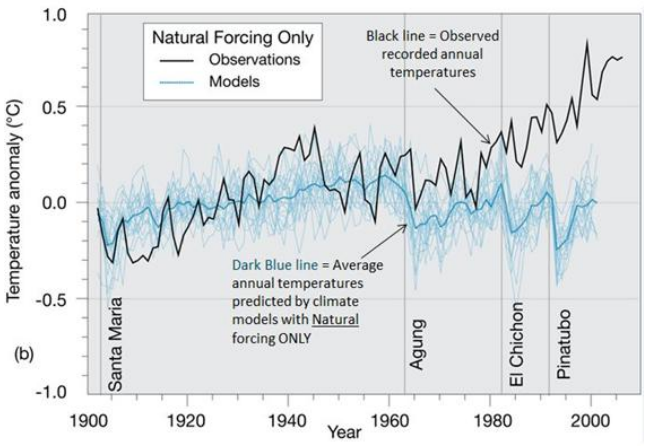
POSSIBLE QUESTIONS ON NATURAL & ANTHROPOGENIC FORCING:

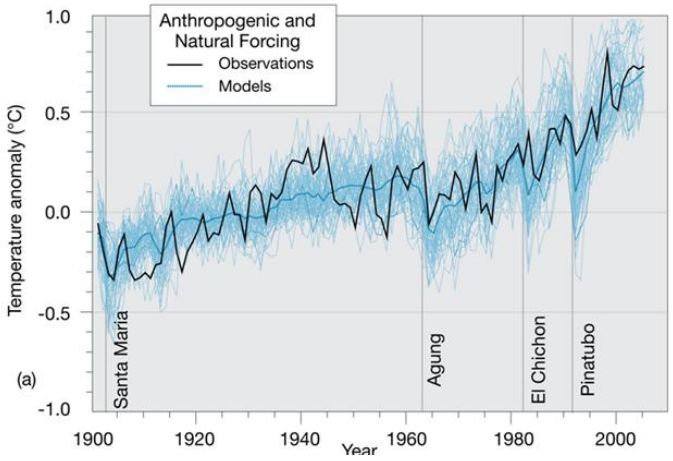
31. Here is the "Hockey Stick" graph (below left) and the updated and more robust version of this graph (the Spaghetti Plate) from the more recent IPCC (below right). What is the key conclusion that can be drawn from these graphs and why is it necessary for the "deniers' to discredit these graphs in order to make their case that humans are NOT responsible for recent global warming?





32. What do these figures depict and what is their significance in the global warming debate?





POSSIBLE QUESTIONS on THE CLIMATIC EFFECTS OF EXPLOSIVE VOLCANISM:

33. Could you pick out the proper climatic responses in both the stratosphere and troposphere after a large volcanic eruption (one with lots of sulfate aerosols)? *(see p 72-75 of CLASS NOTES).*

34. Could you identify what features make a volcanic eruption climatically effective? *(see p 73 of CLASS NOTES).*

35. Which of the following is **NOT** one of the **typical scenarios** associated with a **large, climatically effective explosive eruption**:

a) Sulfur dioxide gas injected into the stratosphere converts to a sulfate aerosol cloud which **reflects some incoming solar shortwave (SW)** radiation back to space, *cooling the troposphere*

b) Sulfur dioxide gas injected into the stratosphere converts to a sulfate aerosol cloud which **absorbs** some wavelengths of incoming **SW radiation** and some of the Earth's **outgoing longwave (LW)** radiation, *warming the stratosphere*

c) Most of the eruption occurs as **lava** flowing out of the volcano and whatever **ash** is ejected *stays in the troposphere* and *quickly falls out of the atmosphere* within a few 100 kilometers

POSSIBLE QUESTIONS on THE CLIMATIC EFFECTS OF SOLAR VARIABILTY AS SEEN IN SUNSPOTS

36. What is the role of solar forcing and sunspots in the global warming trend of recent decades:

a) Sunspots have decreased during the "Modern Minimum" thereby making the sun brighter and adding to global warming.

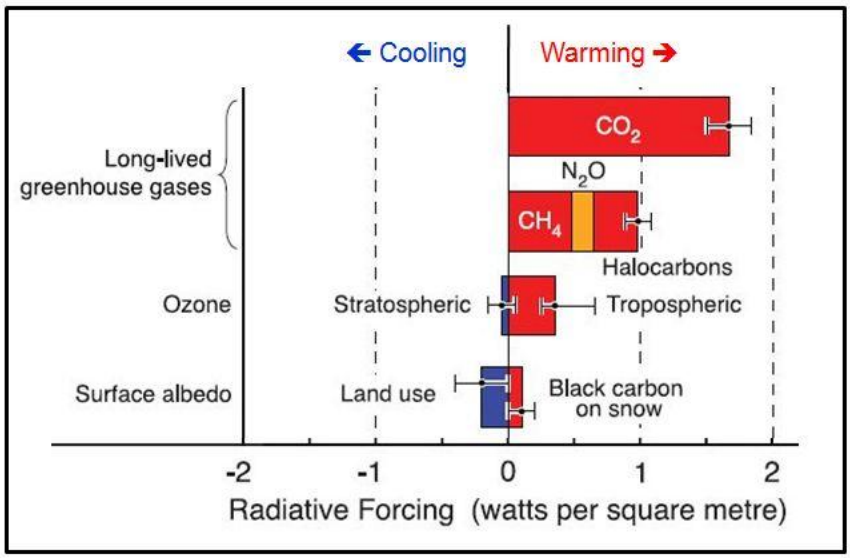
b) Sunspots have increased during the "Modern Maximum" thereby increasing solar brightness and contributing somewhat to the temperature increase since 1970.

c) Sunspots have decreased during the "Maunder Minimum" thereby making the sun brighter and adding to global warming.

d) Sunspots have increased during the "Maunder Maximum" thereby increasing solar brightness and contributing somewhat to the temperature increase since 1970.

POSSIBLE QUESTIONS ON RADIATIVE FORCING:

37. The figure at right contrasts the role of **stratospheric vs. tropospheric ozone** in radiative forcing (cooling or warming) of the global temperature.



Check the phrases below that are correct interpretations of how to read the ozone portion "bar" of the figure:

___ the **blue bar** representing **stratospheric ozone** is **to the left of the zero line** and hence this means that as stratospheric ozone increases, the radiative response will be that of C**OOLING**

___ the **blue bar** representing **stratospheric ozone** is **to the left of the zero line** and hence this means that as stratospheric ozone increases, the radiative response will be that of **WARMING**

___ the **red bar** representing **tropospheric ozone** is **to the right of the zero line** and hence this means that as tropospheric ozone increases, the radiative response will be that of C**OOLING**

___ the **red bar** representing **tropospheric ozone** is **to the right of the zero line** and hence this means that as tropospheric ozone increases, the radiative response will be that of **WARMING**

38. Now complete the following explanation of the figure by circling the correct words in the brackets and filling in the blank with the appropriate word or phrase to make the statement correct.

If stratospheric ozone DECREASES and tropospheric ozone INCREASES, the radiative forcing response will be that of **[warming / cooling]** *(circle one)* -- but for two different reasons: Stratospheric ozone primarily affects the **[UV / IR]** *(circle one)* part of the spectrum, while tropospheric ozone primarily affects the **[UV / IR]** *(circle one)* part of the spectrum parts of the electromagnetic spectrum.

The combined influence on GLOBAL WARMING of stratospheric ozone depletion and an increase of tropospheric ("bad ozone") is _____ (small, large, etc.)
when compared to the radiative forcing influence of the other Greenhouse gases shown in the figure.

POSSIBLE QUESTIONS ON DEFORESTATION:

39. Which of the following is a likely consequence of **deforestation**

a) *an increase* in surface albedo
b) the need for an adjustment of the steady state of carbon moving into and out of the atmosphere
c) a decrease in energy in LE and an increase in energy in H.
d) all of the above

OTHER MISCELLANEOUS PRACTICE QUESTIONS:

40. The **evidence** that ***atmospheric CO_2*** has been increasing in recent decades is:

a) still being hotly debated among most global change scientists
b) somewhat uncertain and based only on one measuring site at Mauna Loa
c) accepted by the IPCC scientists, but not by the global warming deniers
d) accepted as "indisputable" by nearly all global change scientists

41. Which of the following statements most accurately expresses the findings of the most recent IPCC report and the overwhelming consensus of scientific studies of climate:

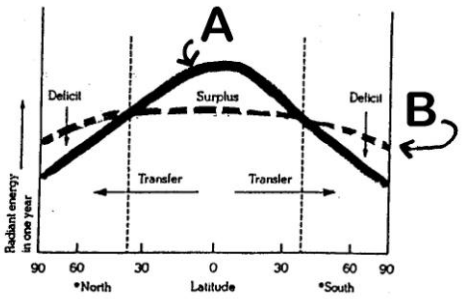
a) Emissions from the widespread burning of fossil fuels since the start of the Industrial Revolution have increased the concentration of greenhouse gases in the atmosphere. In response, natural processes have operated quickly to remove carbon dioxide from the atmosphere, thereby leading to a balanced steady state with no net increase over time in greenhouse gas concentrations or in global average temperature.

b) The warming of the climate system is unequivocal and most of the observed increase in global average temperatures since the mid twentieth century is very likely due to the increase in anthropogenic greenhouse gas concentrations.

c) Based on evidence from tree rings, other natural records, and scientific observations made around the world, Earth's average temperature is now warmer than it has been for the last 200 years, although not as warm globally as during medieval times from about 1000-1200 A.D.

d) Natural processes driving the Earth's long-term climate variability can explain the rapid climate change observed in recent decades hence there is insufficient evidence that human impacts have played a major role in these changes.

YOU WILL DEFINITELY SEE SOME VERSION OF THE FOLLOWING QUESTION (OR PART OF IT) ON THE FINAL EXAM. IT TIES A LOT OF CONCEPTS TOGETHER:

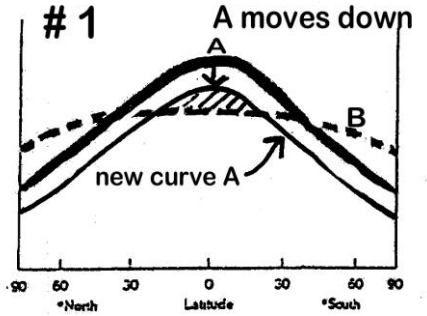


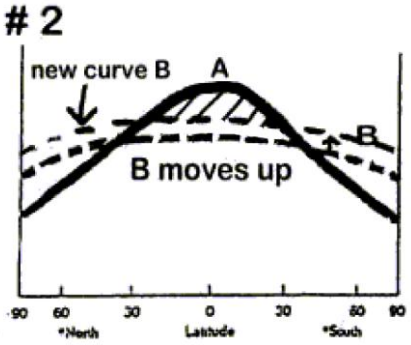
For Questions 42 – 46 below:

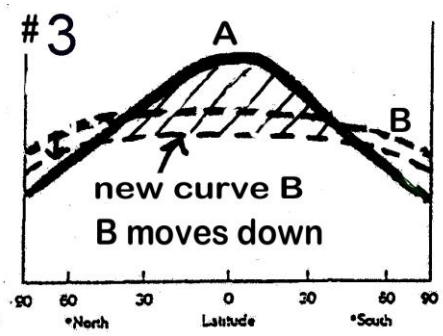
At right is the graph showing annual incoming SW solar radiation absorbed in the troposphere's earth-atmosphere system and outgoing LW terrestrial radiation leaving the tropospheric earth-atmosphere system at various latitudes.

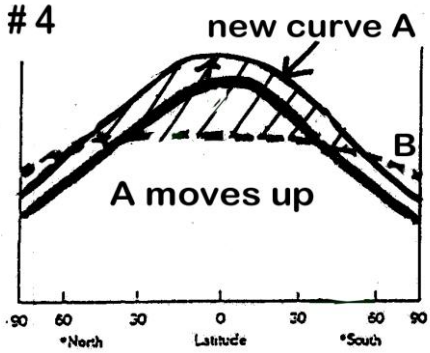
A = solid curve = incoming shortwave (solar) radiation
B = dashed curve = outgoing longwave (terrestrial) radiation

Below are **4 NEW graphs** (#1 through #4) which show a **change in the Earth-atmosphere system's energy balance**. The change is represented by a **shift up or down by either Curve A or Curve B** on each graph. For each question below, **assume only one of the curves (A or B) moves up or down initially** (even though in the real world an adjustment in the other curve might eventually occur in some cases).









42. Which of the four graphs above ***best depicts*** how the energy balance would initially change **if the solar constant were to INCREASE**, sending more shortwave solar energy to the earth at all latitudes.

a) Graph #1 b) Graph #2 c) Graph #3 d) Graph #4

43. Which of the four graphs above ***best depicts*** how the energy balance would initially change if **a major volcanic eruption** (like Krakatoa or Pinatubo) occurred . Assume the **eruption produced a long-lived aerosol veil in the stratosphere** over all latitudes, and reflected large amounts of incoming solar radiation back to space before it ever entered the tropospheric earth-atmosphere system

a) Graph #1 b) Graph #2 c) Graph #3 d) Graph #4

44. Which of the four graphs above best depicts how the energy balance would initially change with a **WEAKER greenhouse effect than today's:**

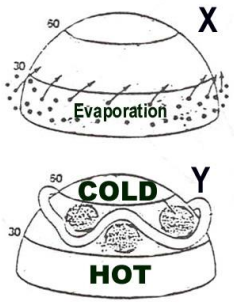
a) Graph #1 b) Graph #2 c) Graph #3 d) Graph #4

45. Which of the four graphs above best depicts how the graph would change if massive desertification and deforestation were to take place, altering the reflectivity of the surface of the earth such that the albedo of the earth-atmosphere system ***increased*** from its current value of 30% up to 45%?

a) Graph #1 b) Graph #2 c) Graph #3 d) Graph #4

POSSIBLE FOLLOW-UP SHORT ANSWER QUESTION

Refer to the figure below in your explanations:



46. The figure shown at the top of the previous page indicates that on an annual basis there is a **deficit** of energy in the **high** latitudes and a **surplus** of energy in the **low** latitudes. In the spaces below, briefly explain how *atmospheric processes* that involve energy in (a) **H (sensible heat) form,** and (b) **LE (latent energy) form**, transport energy across latitudes to balance out the low-latitude surplus and the high-latitude deficit.

(a) How energy transport across latitudes happens in **H (sensible heat) form**:

(b) How energy transport across latitudes happens in **LE (latent energy) form**:

POSSIBLE ESSAY QUESTIONS:

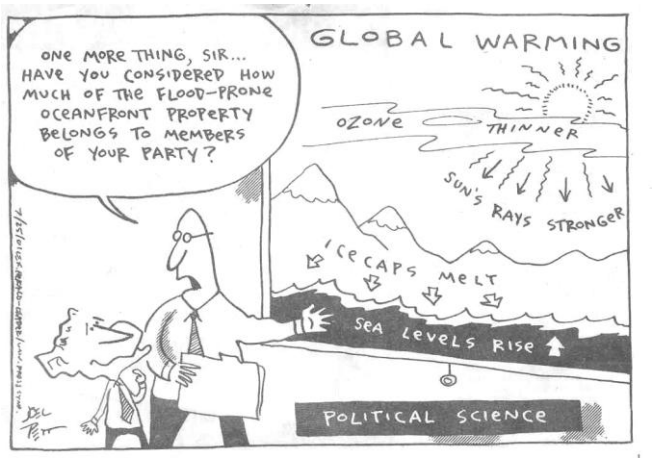
47. Following is an excerpt from an opinion article that appeared in the *Tucson Citizen* titled "Global warming theory appears to be a lot of hot air." Based on what you've learned this semester, evaluate the excerpt for correctness and **UNDERLINE the scientifically incorrect phrase it contains**:

"Greenhouse refers to carbon-dioxide emissions from the world's use of fossil fuels, which in turn are said to be depleting the ozone layer – the layer that protects humankind from dangerous ultraviolet radiation."

Now in the space below, REWRITE the journalist's short explanation of the greenhouse effect and the depletion of the ozone layer using scientifically accurate terminology and explanations:

ANOTHER POSSIBLE (somewhat related) ESSAY QUESTION (see the cartoon below – it should be familiar by now!)

48. Many people think the physical processes associated with stratospheric ozone depletion are the same as the physical processes associated with the anthropogenically enhanced greenhouse effect. They then mix both concepts together into an explanation of global warming, as does this scientifically inaccurate cartoon at right ==>



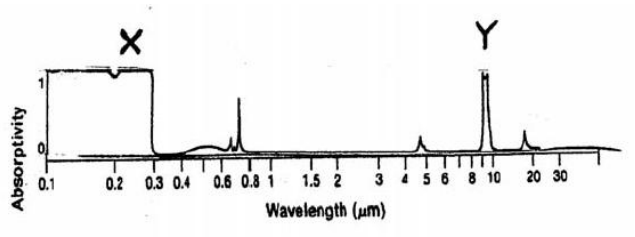
In a 3-part essay, explain the following:

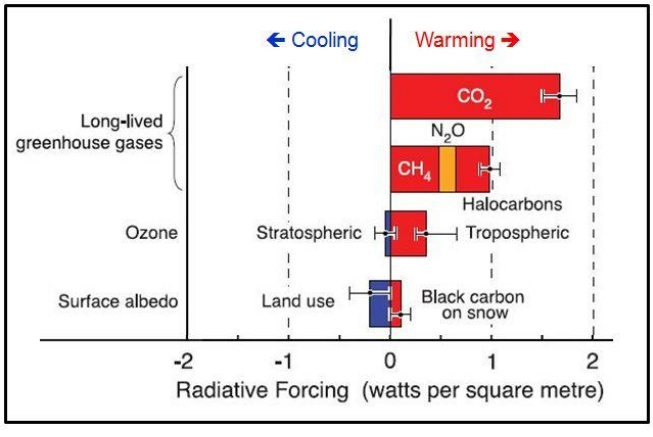
a) WHY is the cartoon's depiction of thinner ozone as the principle cause for global warming incorrect?

b) WHAT IS the principle cause for anthropogenically produced global warming according to the IPCC scientists?

c) HOW -- if at all -- IS ozone linked to global warming?

In your answer, refer to the ABSORPTION CURVE OF OZONE and the RADIATIVE FORCING DIAGRAM shown below:





49. ESSAY QUESTION ON THE GREENHOUSE EFFECT:

In class we discussed these three "cartoon" figures and used the Clickers to select the one that is a more accurate depiction of the processes involved in the greenhouse effect.

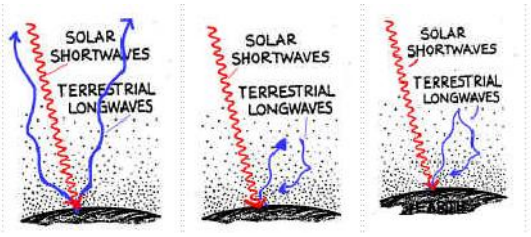


Figure X Figure Y Figure Z

(a) Which figure above is the **more accurate depiction of the greenhouse effect**? Figure ____ *(fill in the blank)*

(b) On the figure you selected, **CIRCLE the part of the diagram which represents the energy processes DIRECTLY involved** in the greenhouse effect.

(c) Explain **WHY** the figure you selected is a more accurate depiction of the Greenhouse Effect **than the other two figures.**

(d) Finally, give a precise and scientifically accurate DEFINITION of the natural Greenhouse Effect in your own words.

One other possible short essay question:

50. In 2006, the Supreme Court ruled on whether the Environmental Protection Agency has the authority to regulate air pollutants associated with climate change under the Clean Air Act. Massachusetts Assistant Attorney General James R. Milkey faced skeptical questioning from Chief Justice John G. Roberts Jr. and Justice Samuel A. Alito Jr. . . but the most sustained-- and entertaining -- interrogation came from Justice Antonin Scalia:

At one point, [Scalia] acknowledged the role of carbon dioxide as a pollutant in the air but wondered about it being a pollutant in the "stratosphere."

"Respectfully, Your Honor, it is not the stratosphere. It's the troposphere," Milkey said.

"Troposphere, whatever. I told you before I'm not a scientist," Scalia said to laughter. "That's why I don't want to have to deal with global warming, to tell you the truth."

Source: http://www.climatesciencewatch.org/2006/11/30/documents-in-supreme-court-case-on-greenhouse-emissions-regulation/

QUESTION: Write an email to Justice Scalia explaining to him what the troposphere is and that there is a difference between the troposphere and stratosphere. Then give at least two reasons why it is important to make a distinction between these two layers -- especially with respect to the two global change issues of global warming and stratospheric ozone depletion.